Journal of the Minnesota Academy of Science

Volume 27 | Number 1 Article 21

1959

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A. J. Linck
University of Minnesota

Theodore W. Sudia
University of Minnesota

BOTANY

TRANSLOCATION OF PHOSPHORUS-32 IN PISUM SATIVUM [1]

A. J. LINCK and THEODORE W. SUDIA
University of Minnesota, St. Paul

INTRODUCTION

Minerals are absorbed from the soil by plant roots, carried to the leaves and other aerial parts, then distributed in various compounds to other parts of the plant (Biddulph *et al.* 1958; Swanson and Whitney, 1953); minerals may be carried upward or downward in the phloem (1, 2) and have been shown to move through the phloem from the leaf to the stem of peas (Linck, 1955). 50% or more of the phosphorous ^{32} from a leaf at the same node to which a fruit was attached moved to the fruit (Linck, 1955). The aim of the tests reported here was to further delineate the course of phosphate transport in the stems of peas.

MATERIALS AND METHODS

Pea plants (*Pisum sativum*, variety Alaska) were grown in the greenhouse until the pods reached mature size. Plants grown in this manner were then divided into three groups for treatment. One set of plants was not girdled and served as checks. The other two sets of plants were steam-girdled either above or below the leaf to which phosphorus ^{32} was applied (see Fig. 1). The girdling was accomplished by training a small jet of live steam in the center of the internode either above or below the node to which the phosphorus ^{32} was applied. After girdling 7.8 uc. of phosphorus ^{32} in a 10 lambda drop in the form of $H_3P^{32}O_4$ was applied to a leaflet of the leaf two nodes below the fruit bearing node (referred to as the "supply" leaf). All plants had only one fruit per plant. The plants were allowed to absorb phosphorus ^{32} for three hours before harvesting according to the plan in Fig. 1. The plant parts were oven dried at 60° C, and digested with concentrated nitric acid. The plant parts thus prepared were assayed for radioactivity in a Geiger counter and the relative amounts of phosphorus ^{32} expressed in counts per minute (cpm).

The effect of girdling was intended to indicate whether or not the phosphorus ^{32} moved up or down the stem in the phloem. This treat-

[1] Paper No. 4122, Scientific Journal Series, Minnesota Agricultural Experiment Station. Research supported in part by an Atoms for Agriculture Grant and by the United States Atomic Energy Commission. Contract AT (n-i) 783.

ment is thought to intercept the phloem while leaving the xylem functional.

The results given are from one experiment and agree with the results of a second experiment which will not be reported here. In the second experiment there were five plants per treatment.

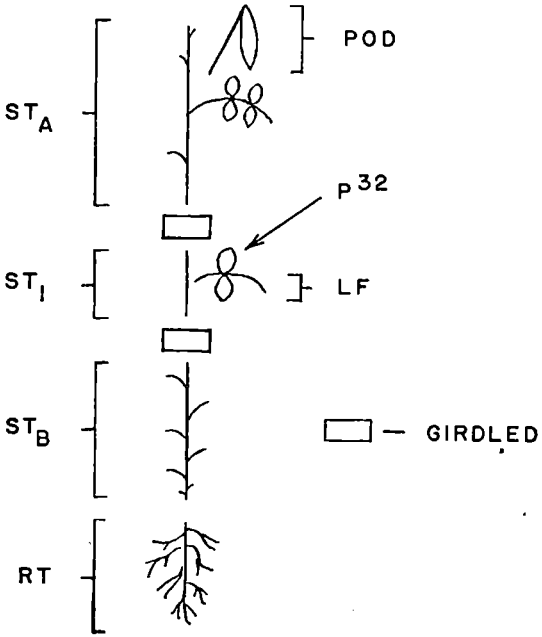

FIGURE 1. Diagram of a pea plant showing where the stem was steam-girdled either above or below the leaf to which the phosphorus—32 was applied. Parts of the plant assayed at the end of the experiment were: ST_A—stem and leaves above the "supply" leaf (LF); ST_B—stem and leaves below the "supply" leaf; and ST_I—the stem between the ST_A and ST_B parts. Roots (RT) were not assayed.

RESULTS AND DISCUSSION

When phosphorus ^{32} is applied to a leaflet attached two nodes below the node bearing a pod, a considerable amount of the phosphate moves into the pod at that node (Table 1). This distribution pattern of phosphorus ^{32} movement was used as a "model system" on which this study was performed.

In plants in which translocation was unrestricted, i.e., the plants were not girdled, 46% of the activity recovered was found in the pod compared to 3% when the stem was girdled above the supply leaf and 37% when the stem was girdled below the supply leaf (Table 2). The striking reduction in transport to the pod when the phloem is intercepted is also seen in the actual activity data (Table 1) where the pod activity is reduced from over 6000 cpm. to 54 cpm. It should be noted that the total activity recovered in the above-ground parts of

Table 1. THE DISTRIBUTION OF PHOSPHORUS–32 FROM A LEAF WHEN THE STEM IS STEAM-GIRDLED EITHER ABOVE OR BELOW THE NODE OF ATTACHMENT OF THE "SUPPLY" LEAF.

Stem treatment above or below "supply" leaf	Counts per minute per plant part[1]					
	St_B	St_A	St_I	Pod	Leaf[2]	Total
Not girdled	2749	843	2298	6007	1143	13040
Girdled below	3	2238	1347	2825	1077	7490
Girdled above	691	94	645	54	138	1622

[1] Figures based on 3 plants per treatment.
[2] Leaf—included the petiole and opposite leaflet from the leaflet to which the phosphorus–32 was applied. This latter leaflet was discarded.

Table 2. THE PERCENTAGE DISTRIBUTION OF PHOSPHORUS–32 IN AERIAL PARTS OF PEA PLANTS WHICH HAD BEEN GIRDLED ABOVE OR BELOW THE LEAF TO WHICH THE PHOSPHORUS–32 WAS APPLIED.

Stem treatment above or below "supply" leaf	Percentage of total activity recovered in aerial parts of the plant[1]				
	St_B	St_A	St_I	Pod	Leaf[2]
Not girdled	21	6	18	46	9
Girdled below	0	30	18	38	14
Girdled above	43	6	40	3	8

[1] Figures based on 3 plants per treatment.
[2] Leaf—included the petiole and opposite leaflet from the leaflet to which the phosphorus–32 was applied. This latter leaflet was discarded.

the plant is greatest where no part of the steam was girdled and least when the girdle occurred above the supply leaf.

When the stem was girdled above the leaf to which the phosphorus ^{32} was applied the amount of activity translocated to the upper vegetative parts of the plant (St_A) was reduced from 843 cpm. to 94 cpm. The amount moving downward in these plants (into the St_B part) was also reduced. This is in agreement with the "remote control" effect of treatments on one part of the vascular system which affects translocation to other parts of the system. (Böhning et al. 1952).

When the stem was girdled below the supply leaf, activity in the lower stem (St_B) was reduced from 2749 cpm. in the non-treated to 3 cpm. in the girdled plants. Less phosphorus ^{32} moved to the pod also, but somewhat more phosphorus ^{32} was recovered in the St_A portion of the upper stem. No explanation can be given for these latter aspects of the translocation pattern.

SUMMARY

More than 40% of the phosphorus ^{32} which moved into aerial parts of peas (*Pisum sativum* variety Alaska) from a leaf two nodes below

the first bloom node was translocated to this pod. When the stem was steam-girdled in the internode above the leaf supplying phosphorus ^{32} to the plant, movement to this same pod was almost completely stopped. Plants girdled in this way had less activity in all plant parts when compared to non-girdled plants. Steam-girdling plants in the internode below the phosphorus ^{32} supply leaf resulted in less phosphorus ^{32} moving downward through the girdled zone. These results suggest that translocation of phosphorus ^{32} both upward and downward in the stem of peas from the leaves is via the living phloem.

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